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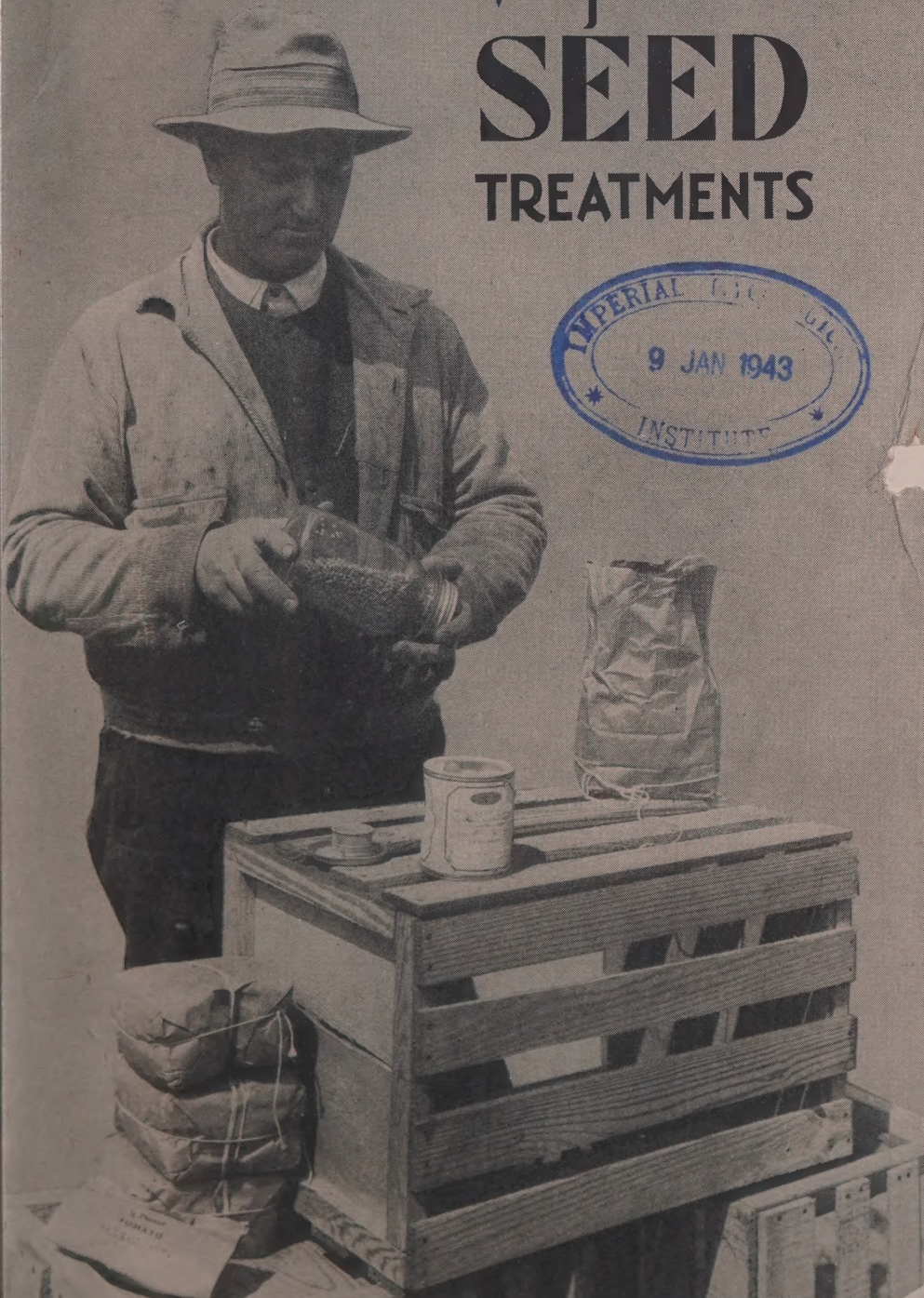
Vegetable SEED TREATMENTS



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UNITED STATES DEPARTMENT OF AGRICULTURE

THE seed treatments suggested in this bulletin are based on investigations and recommendations of Federal and State research and extension workers. Preferred treatments and methods of applying them may vary in different States or localities. New treatments are continually being discovered as a result of research. It is, therefore, difficult to make a set of recommendations that will be applicable to all parts of the country.

The object of this bulletin is to bring together the recommendations for treating the different kinds of vegetable seeds. The diseases that are affected by the treatments are indicated, and abbreviated directions for applying the treatments are given. In many instances a choice of several treatments is given, and in those cases, unless there is some obvious reason, no preference is expressed. In some cases a double treatment, in order to disinfect as well as to protect the seed, is desirable. The reader should decide which treatments seem best for his situation. In case of doubt he should confer with his county agricultural agent or get in touch with his State college of agriculture or experiment station.

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VEGETABLE SEED TREATMENTS

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INTRODUCTION

Many diseases of vegetable crops are caused by bacteria or fungi that are carried in, on, or with the seed. Disinfection of the seed to kill these parasites is one of the important ways of fighting vegetable diseases. The application of heat by soaking seeds in hot water is sometimes effective in destroying certain internally borne, as well as surface borne, organisms. Various chemical disinfectants have been found that will kill externally borne plant parasites.

Within the past few years chemical treatments have also come into use for the purpose of protecting seeds and seedlings from attacks of decay-producing organisms that may be in the soil or on the seed. These treatments protect the seeds and young, developing seedlings from excessive damping-off and thereby often aid in improving stands and yields.

Seed treatments therefore fall into two groups: (1) Seed disinfectants and (2) seed protectants. Of the seed disinfectants the most commonly used are bichloride of mercury (corrosive sublimate), some of the organic mercury compounds, formaldehyde, and hot water. Of the seed protectants the organic mercuries, copper compounds, and zinc oxides are most prominent at the present time. Most seed-treating chemicals have value both as disinfectants and protectants in varying degrees.

It should be remembered that seed treatments alone cannot always be relied on to control all diseases against which they are directed. They are not panaceas. Sometimes a seed treatment will of itself be entirely effective in preventing the occurrence of disease, but more often it is only one step in a series of disease-control practices. Disease germs are harbored in other places besides the seed, such as in old crop refuse, in the seedbed, greenhouse, or field, on sash and frames, in the soil, and on closely related weeds. Therefore, such practices as seedbed and field sanitation, rotation, destruction of weed carriers, and spraying may be necessary in order to secure successful disease control.

SEED-TREATMENT CHART

[See the following pages for detailed directions]

Crops and diseases	*Seed treatments* (Numbers refer to descriptions of treatments following)
Asparagus (seed):	
Damping-off	Organic mercury (7, p. 8).
Bean:	
Damping-off	Organic mercury (7, p. 8).
Beet, garden:	
Leaf spot	Formaldehyde (18, p. 12).
Damping-off	Cuprous oxide (16, p. 9), organic mercury (7, p. 8), bluestone (15, p. 9).
Broccoli:	
Black rot	Corrosive sublimate (1, p. 5), hot water (21, p. 15).
Black leg	Hot water (21, p. 15).
Alternaria blight	Hot water (21, p. 15).
Damping-off and wire stem	Calomel (2, p. 7), zinc oxide (17, p. 11), organic mercury (7, p. 8).
Maggot and damping-off	Calomel (2, p. 7).
Brussels sprouts	See Broccoli.
Cabbage	See Broccoli.
Carrot:	
Damping-off	Cuprous oxide (16, p. 9), organic mercury (7, p. 8), bluestone (15, p. 9).
Cauliflower	See Broccoli.
Celery:	
Bacterial blight	Corrosive sublimate (1, p. 5), calomel (2, p. 7), formaldehyde (18, p. 12), hot water (21, p. 15).
Late blight, early blight	Same as for bacterial blight above; use aged seed (24, p. 17).
Damping-off	Organic mercury (7, p. 8), calomel (2, p. 7), cuprous oxide (16, p. 9).
Celeriac	See Celery.
Collard	See Broccoli.
Corn, sweet, and popcorn:	
Seed decay, seedling blight	Organic mercuries (6, p. 8, 9, p. 8, 10, p. 9).
Cucumber:	
Anthracnose	Corrosive sublimate (1, p. 5).
Scab	Corrosive sublimate (1, p. 5).
Angular leaf spot	Corrosive sublimate (1, p. 5).
Damping-off	Red copper oxide (16, p. 9), organic mercury (7, p. 8).
Eggplant:	
Phomopsis blight	Corrosive sublimate (1, p. 5), hot water (21, p. 15).
Damping-off	Cuprous oxide (16, p. 9), organic mercury (7, p. 8), bluestone (15, p. 9).
Endive:	
Damping-off	Organic mercury (7, p. 8), cuprous oxide (16, p. 9), bluestone (15, p. 9).
Escarole:	
Damping-off	Organic mercury (7, p. 8), cuprous oxide (16, p. 9).

Crops and diseases	*Seed treatments* (Numbers refer to descriptions of treatments following)
Horseradish (roots):	
Bacterial root rot	Corrosive sublimate (1, p. 5).
Horseradish (seed):	
Damping-off	Organic mercury (7, p. 8), cuprous oxide (16, p. 9), zinc oxide (17, p. 11).
Kale:	
Black rot	See Broccoli.
Kohlrabi	See Broccoli.
Lettuce:	
Damping-off	Cuprous oxide (16, p. 9).
Lima, bean:	
Damping-off	Spergon (25, p. 17).
Muskmelon	See Cucumber.
Mustard	See Broccoli.
Onions:	
Alternaria blight	Hot water (21, p. 15) (helpful).
Damping-off	Organic mercury (7, p. 8).
Damping-off and maggots	Calomel (2, p. 7).
Downy mildew	Hot water (21, p. 15) (helpful).
Smut	Formaldehyde drip (18, p. 12).
Parsley:	
Damping-off	Organic mercury (7, p. 8).
Parsnip:	
Damping-off	Organic mercury (7, p. 8).
Pea:	
Damping-off, leaf and pod spots, root rot.	Cuprous oxide (16, p. 9), Spergon (25, p. 17), organic mercury (7, p. 8).
Peanut:	
Damping-off	Organic mercury (7, p. 8).
Pepper:	
Anthracnose	Bluestone (15, p. 9).
Bacterial spot	Corrosive sublimate (1, p. 5).
Black spot (alternaria blight)	Bluestone (15, p. 9).
Cercospora leaf spot	Corrosive sublimate (1, p. 5).
Damping-off	Cuprous oxide (16, p. 9), bluestone (15, p. 9), organic mercury (7, p. 8).
Potato, white:	
Rhizoctonia	Corrosive sublimate (1, p. 5), yellow oxide of mercury (3, p. 7), organic mercuries (8, p. 8, 11, p. 9, 12, p. 9), formaldehyde (18, p. 12).
Scab	Formaldehyde (18, p. 12).
Pumpkin	See Cucumber.
Radish	See Broccoli. (Of doubtful value.)
Romaine:	
Damping-off	Organic mercury (7, p. 8), cuprous oxide (16, p. 9).
Rhubarb (roots):	
Foot rot and crown rot	Corrosive sublimate (1, p. 5), formaldehyde (18, p. 12).
Rutabaga	See Broccoli.
Salsify:	
Damping-off	Organic mercury (7, p. 8), cuprous oxide (16, p. 9).
Spinach:	
Damping-off	Cuprous oxide (16, p. 9), zinc oxide (17, p. 11), organic mercury (7, p. 8), bluestone (15, p. 9).
Squash	See Cucumber.
Sweet corn	See Corn.
Sweetpotato (roots):	
Black rot and scurf	Corrosive sublimate (1, p. 5), organic mercury (8, p. 8).

Crops and diseases	*Seed treatments* (Numbers refer to descriptions of treatments following)
Swiss chard:	
Damping-off	Cuprous oxide (16, p. 9), organic mercury (7, p. 8), bluestone (15, p. 9).
Tomato:	
Alternaria collar rot and blight	Organic mercury (5, p. 8), corrosive sublimate (1, p. 5), hot water (21, p. 15).
Bacterial spot	Organic mercury (5, p. 8), corrosive sublimate (1, p. 5), hot water (21, p. 15).
Bacterial canker	Acetic acid (23, p. 16), fermentation soak (22, p. 16), corrosive sublimate (1, p. 5), organic mercury (5, p. 8), hot water (21, p. 15).
Damping-off	Cuprous oxide (16, p. 9), organic mercury (7, p. 8), bluestone (15, p. 9).
Turnip	See Broccoli. (Of doubtful value.)
Watermelon	See Cucumber.

TREATMENTS COMMONLY USED FOR DISINFECTING AND PROTECTING SEEDS, ROOTS, AND TUBERS [1]

All the chemicals mentioned in the following treatments are injurious to man and animals when taken internally; some of them are extremely so. Therefore care should be taken in handling any of them. When these chemicals are used in dust form, care should be taken not to inhale them. When large quantities of seed are being treated with these dusts, a dust mask should be worn, but this is not necessary when small quantities of seed are treated if the treating is done in the open air or in a well-ventilated room. If the chemical is used in liquid form, care should be taken in pouring out the used solution to see that it does not stand in puddles but soaks into the ground. Powders and tablets of these chemicals should be kept in a safe place out of reach of children and others.

1. **Corrosive Sublimate (Mercuric Chloride, Bichloride of Mercury).**—This disinfectant may be purchased in powdered or tablet form and is used mostly at the 1–1,000 strength. This is equivalent to—

   4 ounces to 30 gallons of water.
   1 ounce to 7½ gallons of water.
   8 tablets (7½ grains) to 1 gallon of water.
   1 tablet (7½ grains) to 1 pint of water.

The temperature of the solution is important. At low temperatures (40° F.) the reaction is very slow; at high temperatures the reaction is rapid. Treatments are supposed to be given at about room temperature, 60° to 70°, unless otherwise indicated. The chemical corrodes metals; therefore, nonmetallic containers made of wood, earthenware, glass, or enamelware should be used.

As the chemical in powdered form is slowly soluble in cold water, a small quantity of hot water should be used to bring it into solution. Common salt in equal quantity added to the powder will help dissolve it but slightly weakens the solution.

The seed is treated in bulk or is put in loose cloth sacks and suspended in the solution for the required time.

The solution loses strength with each successive treatment. It should be renewed or brought back to its original strength frequently. The following chemical test to determine how much fresh solution to add may be of use to commercial treaters or to those having large amounts of seed to treat.

Dissolve about 5 grams (one-sixth ounce) of potassium iodide crystals in 1,000 cc. (about 1 quart) of water. Add 1 gram of copper sulfate which has been dissolved in a little of the water. Pour a definite amount (about 10 cc.) of this solution into a tall glass measur-

[1] Proprietary names are given for many of the chemicals used in these treatments, because the only name in general use is the proprietary trade name. The treatments described in the following pages are intended to include all seed disinfectants that at the time of publication met State and Federal specifications.

ing cylinder. Now add some of the freshly prepared corrosive sublimate treating solution (1–1,000 strength) very slowly, shaking the cylinder, until an orange precipitate begins to form. Record the amount of corrosive sublimate solution needed to produce the orange color.

To test the strength of a corrosive sublimate solution that has been used add water to it to bring it up to its original volume and then add some of it very slowly to the definite amount of potassium iodide test solution in the glass cylinder. When the orange precipitate begins to form, record the amount of corrosive sublimate solution added. The fraction represented by the original amount over this larger amount represents the extent to which the solution has been weakened. For example, if 2 parts of corrosive sublimate produced the orange color in the first test and 3 parts were required to produce it in the second test, the solution has been weakened to two-thirds of its original strength, and one-third more corrosive sublimate should be added.

After treatment, all seeds should be washed in water for about 15 minutes and either sown wet, or quickly dried if they are to be stored. If a large quantity of seed is to be treated, it is good practice to run a treatment and germination test on a small sample before disinfecting the entire lot. Keep in mind that it is better to kill a few seeds than to chance the crop's being ruined by disease.

BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, COLLARD, KALE, KOHLRABI, RADISH, RUTABAGA, TURNIP, AND OTHER CRUCIFERS.—Use 1 part corrosive sublimate to 1,000 parts of water (1 ounce to 7½ gallons). Soak the seeds for 20 minutes, wash 15 minutes, dry.

CELERY.—Presoak the seeds in water at room temperature for one-half hour; then soak in 1–1,000 (1 ounce to 7½ gallons) solution for 15 minutes, wash 15 minutes, and dry. Treatment may decrease germination. Safe only with new, vigorous seed.

CUCUMBER.—Use 1–1,000 solution (1 ounce to 7½ gallons). Soak the seed 5 minutes, wash 15 minutes, dry.

EGGPLANT.—Use 1–1,000 solution (1 ounce to 7½ gallons). Soak the seed 10 minutes, wash, dry.

HORSERADISH.—Use 1–1,000 solution (1 ounce to 7½ gallons). Soak the seed for 15 minutes, wash, dry.

PEPPER.—Use 1–1,000 solution (1 ounce to 7½ gallons). Soak the seed for 2 minutes, wash, and then plant them before they dry. Pepper seeds are sensitive to injury by this chemical.

POTATO (WHITE).—The corrosive sublimate treatments for potatoes, namely, the cold, the hot, and the acid treatments, are given primarily for control of tuber-borne rhizoctonia. Although these treatments kill the scab organism on seed tubers, they may actually increase the amount of scab in alkaline or neutral old potato soils. Recent evidence indicates that the tubers of some of the newer, shallow-eyed varieties, such as Katahdin, Chippewa, and Earlaine, may be injured by these and other mercury treatments.

Cold corrosive sublimate treatment.—Use 1–1,000 solution (4 ounces to 30 gallons). Soak the seed potatoes for 1½ hours. Temperature of solution, 50° to 70° F. Do not store wet.

Hot corrosive sublimate treatment.—Use 1–1,000 solution (4 ounces to 30 gallons). Soak the seed potatoes for 2½ minutes at a temperature of 126° F. Do not store wet.

Acid-mercury treatment.—Use 6 ounces to 25 gallons plus 1 quart of commercial hydrochloric acid. Soak the tubers in the solution for 5 minutes, plant immediately, or dry and store. Do not store wet. Twenty-five gallons will treat about 40 bushels; after that quantity has been treated, a new solution should be prepared.

RHUBARB ROOTS.—Use 1–1,000 solution (1 ounce to 7½ gallons). Soak the roots for one-half hour, wash, dry.

SWEETPOTATO.—Use 1–1,000 solution (4 ounces to 30 gallons). Soak the roots 8 to 10 minutes; then bed without washing.

TOMATO.—Use 1–2,000 solution (1 ounce to 15 gallons). Soak the seed 5 minutes, wash 15 minutes, dry.

WATERMELON.—Same as for Cucumber.

2. Calomel (Mercurous Chloride).—Calomel is relatively harmless to plants and therefore may be applied much more freely than corrosive sublimate.

BROCCOLI, CABBAGE, CAULIFLOWER, AND OTHER CRUCIFERS.—If seed is to be planted late enough for cabbage maggot in the seedbed, the following treatment will help control that insect as well as damping-off. Dissolve 4 ounces of powdered gum arabic in a pint of hot water; use 1¼ ounces (2½ tablespoonfuls) of this solution per pound of seed and mix by hand in a flat pan. This acts as a sticker to make the calomel stay on the seed and so increases the efficiency of the treatment. Add 1½ to 2 pounds of calomel (300 mesh or finer) to each pound of this moistened seed and mix thoroughly. The seed will take up most of the calomel. Sift out any not taken up. It is best to treat the seed just before planting. Treated seed should be planted about one-half inch deep.

If seed is planted early enough to avoid maggots in the seedbed, the Semesan seed treatment (No. 7, p. 8) will probably be more satisfactory for control of damping-off and wire stem.

CELERY.—Use 1 ounce to 1 gallon of water. Place the seed in closely woven cloth sacks. Stir the solution vigorously and dip the sacks of seed until the seeds are thoroughly wet. The closely woven cloth permits only the finest particles to cover the seed. Plant the seed immediately or dry it and plant it within 3 to 4 weeks.

ONION.—For damping-off and maggot control on upland soil apply calomel with gum arabic, as described above under Broccoli.

3. Yellow Oxide of Mercury (Mercuric Oxide).—At the present time this is recommended only as an instantaneous dip treatment for seed potatoes.

POTATOES.—Use 1 pound yellow oxide to 30 gallons of water. Dip seed, wetting thoroughly. Drain and plant immediately, or dry and store in a dark place until needed. This chemical is only slowly soluble in the dark but is rather rapidly so in the light; therefore, to avoid injury, store in the dark.

4. 2% Ceresan (Ethyl Mercury Chloride, 2 Percent).—At present this organic mercury is used mostly for treating cottonseed and to some extent sugar-beet and pea seed. Follow directions of the manufacturer.

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5. New Improved Ceresan (Ethyl Mercury Phosphate, 5 Percent).—This organic mercury is used as a dust treatment for cereal seed. Follow the directions on the container. It is also a valuable disinfectant for tomato seed to free it from the fungus *Alternaria* and other organisms. Use 1 ounce in 9 gallons of water and 1 gallon for each pound of seed treated. Soak for 5 minutes, then dry it. Do not store it in tight containers.

6. Semesan Jr. (Ethyl Mercury Phosphate, 1 Percent).

SWEET CORN.—Thoroughly mix 1½ ounces of this organic mercury dust with each bushel of seed corn. A barrel mixer or rotary mixer of some type is needed for the operation. The same treatment can be used on field corn.

7. Semesan (Hydroxymercurichlorophenol, 30 Percent).—This organic mercury is used principally as a protectant on all vegetable seeds listed in chart (pp. 2 and 4) except lettuce and lima beans. Directions for using this material in dust and liquid form on the various vegetable seeds come with each package.

Dust form.—The rate of application for most seeds is half a level teaspoonful per pound of seed, but for string beans, celery, celeriac, onion, parsnip, parsley, and tomato, one-fourth of a level teaspoonful per pound of seed is recommended by the manufacturers. The seeds and the dust are placed in a tight container and vigorously shaken or rotated for 3 to 5 minutes, until all the seeds are thoroughly coated. If peas or other smooth-surfaced seeds are to be planted with a drill, it is desirable to add finely ground powdered graphite at one-half the rate used for Semesan. This will avoid the possible injury to seeds from the drill. Excess dust should be screened off. Store the treated seed in a dry place.

Liquid form.—Soak the seed in a solution made by stirring 1 ounce of Semesan into 3 gallons of water (1 pound to 48 gallons, or 1 level tablespoonful to 1 gallon) for the length of time given in the directions with the package for the particular kind of seeds.

Semesan-treated legume seed, such as peas, cannot be successfully inoculated with nodule-forming bacteria. Cultures should be mixed with sand or soil and broadcast or drilled in the row.

8. Semesan Bel (Hydroxymercurinitrophenol, 12 Percent, and Hydroxymercurichlorophenol, 2 Percent).

POTATO (WHITE).—Mix 1 pound of this organic mercury dust with 7½ gallons of water and dip the seed potatoes. Drain, cut, and plant, or dry and store. One pound treats 60 to 80 bushels of seed. Cut seed can be treated if ordinary precautions are taken to dry it promptly and to provide good aeration if it is necessary to hold the seed for a period before planting.

SWEETPOTATO (ROOTS).—Same as for white potatoes. (See directions on the container.)

9. Barbak C (Mercuric Phenyl Cyanamide and Cadmium Oxide).

SEED CORN.—Use 1½ ounces of this organic mercury dust to each bushel of seed corn (1 teaspoonful to 1 quart of seed). Do not treat damp seed. Keep the seed dry after treatment. Use a mixer so that the seeds may be thoroughly coated with dust. (See directions on label.)

10. **Merko (Hydroxymercury Complex Containing Ammonia).**—Use 2 ounces of this organic mercury dust per bushel of seed, as recommended for Barbak C (No. 9). (See directions on the container.)

11. **Corona P. D. 7 (Combination of 5 Percent of Mercury, 2 Percent of Bromine, and 7 Percent of Phenol).**—A quick dip for seed potatoes. Use 1 pound to 16 quarts of water and immerse the potatoes either cut or whole. Remove the potatoes and drain. Plant them soon after treatment. (See directions on the label.)

12. **Sanoseed Potato Dip (Ethanol Mercuric Chloride, 7.9 Percent).**—This is a quick dip for potatoes. Use according to directions on the package (1 pound to 7½ gallons of water).

13. **Copper Carbonate.**—The use of copper carbonate as a seed disinfectant for the most part has been confined to wheat and sorghum for smut control. It is not usually applied directly to vegetable seeds. However, it may be mixed with water (1 pound to 25 gallons) and applied to the soil as a preemergence and postemergence damping-off preventive.

14. **Basic Copper Sulfates.**—The basic sulfates of copper, of which there are several, are effective seed protectants but seem to be slightly more toxic to seed than cuprous oxide. Therefore they should be used with care on copper-sensitive seeds.

15. **Bluestone (Copper Sulfate, Blue Vitriol).**—Copper sulfate has been largely superseded by some of the newer disinfectants. However, it has special uses on certain seeds and is still used by some growers. It is available in large or small crystals, pulverized form, or as monohydrated copper sulfate.

BEET (TABLE).—Dissolve 2 ounces of bluestone in 1 gallon of water. Tie the seed loosely in cheesecloth and soak for 1 hour. Do not wash. Plant the seed while wet. Dry the seed if it is necessary to hold it before planting.

SPINACH.—Same as for beet.

TOMATO.—Same as for beet. Soak the seed for at least 1 hour (longer soaking will not injure it).

PEPPER.—Presoak the seed in water 6 to 15 hours. Soak in bluestone 1½ ounces to 1 gallon of water for 5 minutes; then dust with air-slaked lime and sow at once.

16. **Cuprous Oxide (Red Copper Oxide, Yellow Copper Oxide).**—This is used as a dust protectant to prevent seed decay and damping-off. The fresh material varies in color from chocolate brown through bright red to yellow, depending on the size of the dust particles, the chocolate brown having the coarsest particle size and the yellow the finest. The finer the particle size, the better the coverage and the smaller the amount of the material needed. Follow the directions of the manufacturer. Keep the seed in an airtight container to avoid spoilage through oxidation.

For small seeds, such as spinach, celery, and carrot, the dosage of cuprous oxide is usually about 1½ percent by weight [2] or 1½ level teaspoonfuls per pound of seed, or 1½ pounds to 100 pounds of seed.

For large seeds, like peas or squash, the dosage may be reduced to 4 ounces per 100 pounds of seed, or one-fourth to one-half a level teaspoonful per pound of seed. The seed and the dust should be mixed thoroughly in a tight container until all the seeds are coated. Any excess dust should be screened off.

When planting treated spinach, peas, and other smooth seeds with a drill, always add a fine-grade graphite powder to the treatment. The friction set up by the cuprous oxide dust slows down the flow of seed, interferes with operation of the drill, and may break the seeds and so reduce the rate of germination. Therefore, add a graphite dust fine enough to pass through a 325-mesh screen. Approved grades are Dixon "Microfyne" and No. 0607. Use one-half as much graphite as cuprous oxide. The two dusts are mixed with the seed at the same time. Use a good rotary mixer. Make at least 200 revolutions at the rate of about 30 revolutions per minute. If the seed is sown by hand, the graphite is not necessary.

Treated seed should not be planted too deeply in seedbeds of pure sand, in dry soil of low organic content, or in very acid soils.

Treated seed may be held for any reasonable length of time if stored dry.

Beet.—Beet seeds respond well to this treatment. They require more dust than smooth seeds of the same size. Use 2 pounds per 100 pounds of seed (2 level teaspoonfuls per pound of seed).

Broccoli, brussels sprouts, cabbage, and other plants of the cabbage family, as well as onions and plants related to them.—These seeds are sensitive to copper injury and therefore should not be treated with cuprous oxide. The zinc oxide, Vasco 4, or Semesan treatments are preferable for crucifers.

Carrot, celery, cucumber, eggplant, endive, escarole, muskmelon, pepper, pumpkin, romaine, salsify, squash, swiss chard, and watermelon.—These seeds respond well to this treatment. Use about 1 pound per 100 pounds of seed, but vary it according to the size of the seed and the recommendations of the manufacturer. The large seeds require the least dust.

Lettuce.—Sometimes lettuce seed is injured by cuprous oxide. It would be well to try out the treatment on a small portion of seed in advance to determine the effect of the chemical under the particular conditions.

Onions, leeks, and chives.—These seeds respond poorly and are likely to be injured. Therefore they should not be treated with cuprous oxide.

Peas.—Early varieties usually respond well. Some later varieties may be injured particularly when planted in dry, sandy, or acid soils. With each bushel of pea seed use 2½ ounces of dust. To avoid seed injury and drill trouble add 1 ounce of very finely pulverized graphite to the 2½ ounces of cuprous oxide and mix both with the seed. If the seed is sown by hand, graphite is not needed.

Spinach.—In early fall plantings especially, spinach often gives greatly increased yields when treated with cuprous oxide. Use it at

[2] Some experiment stations recommend a dosage of 2 percent by weight.

the regular rate of 1½ pounds per 100 pounds of seed. If the seed is planted with a seed drill, add 1½ pounds of finely ground graphite powder (see p. 10) to avoid seed injury and to obtain uniform seeding.

TOMATO.—The dosage recommended for tomatoes is 1½ pounds for 100 pounds of seed or 1½ level teaspoonfuls per pound of seed (fig. 1).

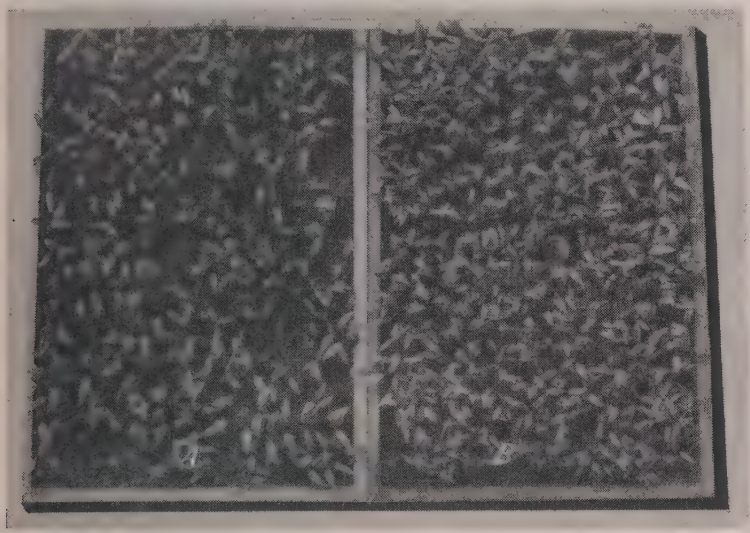

FIGURE 1.—*A*, Tomato seedlings from untreated seed and, *B*, from seed treated with cuprous oxide. (Courtesy of the New York (Geneva) Agricultural Experiment Station.)

17. Zinc Oxide (Zinc White) and Combinations of It With Other Compounds.

BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, HORSERADISH, KOHLRABI, MUSTARD, RADISH, RUTABAGA, SPINACH, AND TURNIP.—As a protectant zinc oxide can be used to advantage on these seeds, most of which are sensitive to injury from cuprous oxide.

The seed should be shaken in a tight container with the dust at the rate of 2 level teaspoonfuls per pound of seed. For large lots of seed use 1½ to 2 percent by weight. Coat the seed thoroughly and screen off any excess of dust.

A commercial zinc oxide and zinc hydroxide combination (Vasco 4) has given good results on spinach (fig. 2) in Virginia and on cabbage and other crucifers in certain other States. It can be used whenever zinc oxide is recommended.

When planting with a drill, spinach, crucifer, and other smooth seed that has been treated with zinc oxide, always add very finely ground graphite powder (see p. 10) to the treatment. As with cuprous oxide, the friction set up by the dust slows down the flow of seed, cracks the seed coats, and interferes with the operation of the drill. Use one-fourth to one-half as much graphite as zinc oxide or Vasco 4. The dust and graphite are mixed with the seed at the same time. Use a good rotary mixer, turning it 200 revolutions at the rate of

FIGURE 2.—*A*, Yield of spinach (192 bushels per acre) from seed treated with zinc oxide; *B*, yield of spinach (143 bushels per acre) from untreated seed. (Courtesy of the Virginia Truck Experiment Station.)

about 30 revolutions per minute. If the seed is sown by hand, the graphite is not necessary.

18. Formaldehyde Liquid (Formalin).

BEET.—The leaf spot fungus is seed-borne, and treating the seed will decrease the amount of early infection. It should be remembered that refuse from preceding beet crops is probably more important as a source of infection. Use 15 parts of liquid formaldehyde to 1,000

parts of water (1 pint to 8 gallons). Dip the seed for 7 minutes, rinse in water, and plant at once or dry.

CELERY.—Presoak the seed in lukewarm water 15 to 30 minutes; then soak in formaldehyde solution (1 tablespoonful to 1 gallon) for 15 minutes. Rinse 15 minutes. This treatment usually causes some retardation.

POTATO (WHITE).—

Cold formaldehyde treatment.—Soak the tubers in a solution made up at the rate of 1 pint to 30 gallons of water for 1½ hours at room temperature, or keep them moist for 1 to 2 hours and then soak in a formaldehyde solution consisting of 1 pint to 30 gallons of water for ½ hour at room temperature.

Hot formaldehyde treatment.—Dip seed potatoes 3 to 4 minutes in a solution made up at the rate of 1 pint of formaldehyde and 15 gallons of water heated to between 124° and 126° F. Because the concentration of the formaldehyde varies considerably, a quick chemical test for determining the strength of the treating solution is available and can be used to good advantage where large quantities of seed potatoes are being treated.

RHUBARB (ROOTS).—Soaking rhubarb roots for ½ hour in 1 pint of formaldehyde to 30 gallons of water is one of the steps in the control of foot and crown rots of rhubarb.

ONION.—For the prevention of onion smut in dry soil apply formaldehyde (1 pint to 16 gallons of water) in the furrow with the seed, using about 16 gallons per 3,000 feet of row (about 200 gallons per acre). In wet soil use 1 pint to 10 gallons of water and apply 125 gallons per acre.

19. Formaldehyde Dust. Although formaldehyde dust has been applied directly to certain seeds as a disinfectant, its primary use in plant-disease control is as a soil and seed treatment in vegetable and flower growing for damping-off control. For this purpose it is not applied directly to the seed but is first mixed with soil in flats, pots, greenhouse benches, or seedbeds. Seeds are then planted in the mixture of dust and soil and then thoroughly watered. This treatment accomplishes a certain amount of disinfection of both soil and seeds. The formaldehyde gas diffuses through the soil and kills damping-off fungi. Figure 3 shows cucumber seedlings growing in untreated soil and those growing in soil treated with formaldehyde dust. This treatment does not replace the steam sterilization or the formaldehyde drench used in greenhouses, nor completely sterilize the soil.

As purchased on the market, formaldehyde dusts are composed of liquid formaldehyde (37 to 40 percent strength) mixed with finely divided inert powders of various kinds and in varying quantities, usually 1 pound of formaldehyde to 5⅔ pounds of inert carrier. They should be applied in accordance with the directions on the packages. As they tend to lose strength rapidly, care should be taken to obtain and use fresh material.

Growers may mix their own dust at a considerable saving by using equal parts of dry, screened, well-rotted compost or peat, and dry loam soil. Dried and screened field muck is also satisfactory. Add

1 pound of liquid formaldehyde to 5⅔ pounds of this material and mix thoroughly in a tight mixing drum. A few stones will aid in the mixing.

If soil is to be used in flats, pots, or benches use this homemade formaldehyde dust at the rate of one-half pound per bushel of soil, mixing thoroughly with a shovel, hoe, or rake. If the dust is to be applied to greenhouse-bench soil mix 2 ounces per square foot if the soil is 2 or 3 inches deep.

Immediately after treating the soil sow the seeds and water the soil thoroughly. With quick-germinating seeds like lettuce, cabbage, and other crucifers it is better to wait 2 or 3 days after treating and watering before sowing, in order to avoid injury.

FIGURE 3.—*A*, Cucumber seedlings from untreated seed and soil, and, *B*, from seed and soil given the formaldehyde-dust treatment. (Courtesy of the Ohio Agricultural Experiment Station.)

Do not place sash or tight covers on treated beds or flats. The formaldehyde fumes must have a chance to escape. In outdoor hotbeds early in the season before it is warm enough to permit free ventilation the use of formaldehyde dust may cause injury to germination. Therefore its use should be limited to greenhouse or open outdoor beds.

20. Concentrated Formaldehyde Soil and Seed Treatment.—A formaldehyde treatment for damping-off control worked out at the New York State College of Agriculture accomplishes about the same results as the formaldehyde-dust treatment (No. 19) at less expense and probably with less trouble. It is used in flats and greenhouse benches.

With a soil mixture of one-half sand and one-half topsoil, 2½ tablespoonfuls of commercial concentrated formaldehyde should be used for each bushel of soil. The formaldehyde is diluted with five or six times its volume of water sprinkled over the soil and thoroughly mixed in. The treated soil is then put in place and allowed to stand from 12 to 24 hours. Then the seeds are sown and the soil thoroughly watered. This watering is very important as it releases formaldehyde and prevents seed injury. With soil mixtures containing more sand and less

soil, it may be desirable to reduce slightly the amount of formaldehyde per bushel. When there is more soil than sand the dosage may be increased. Another very practical method recommended by the New Jersey and Massachusetts Experiment Stations is that of watering the seedbed (flats, hotbeds, ground-bed, boxes, etc.), after the seeds are planted, with 1 ounce (2 tablespoonfuls) of liquid formaldehyde in 3 gallons of water, at the rate of 1 gallon to 5 square feet of seedbed. The area must be accurately known in order to apply the correct amount. It is recommended for seedbeds of beet, chard, cucumber, eggplant, melon, onion, pepper, spinach, and tomato.

21. Hot Water.—Because hot-water treatments sometimes impair germination, especially that of old and weak seeds, it is always well to treat a small sample and to make germination tests before treating large amounts. To insure uniform temperatures it is usually best to treat at one time only small quantities of seed in sacks one-half full in relatively large quantities of water and to stir the water while the treatment is in progress.

After the treatment, spread the seed out in thin layers at once to cool and dry. The seed can be cooled by being plunged in cold water, but hot, wet seed will dry more quickly than cold, wet seed, so that drying by spreading out in a thin layer is perhaps more satisfactory if it can be done quickly. Rapid drying is an essential part of the treatment; therefore attention should be given to stirring the seed and circulation of air. Commercial hot-water treatment should be given where there are adequate artificial drying facilities. An accurate thermometer is necessary for the proper carrying out of this treatment.

The temperatures and length of treatment necessary to control certain diseases of a number of crops are given in table 1.

TABLE 1.—*Temperature and duration of hot-water treatments of certain vegetable seeds*

Crop	Diseases	Temperature	Duration
		° *F.*	*Minutes*
Broccoli	Alternaria blight, Black rot, Blackleg	122	15
Brussels sprouts	Same as for broccoli	122	15
Cabbage	do	122	25
Cauliflower	do	122	15
Celery [1]	Late blight, Early blight, Bacterial blight	118	30
Collard	Same as for broccoli	122	15
Eggplant	Phomopsis blight	122	25
Kale	Same as for broccoli	122	15
Kohlrabi	do	122	15
Onion	Alternaria blight	122	25
	Downy mildew		
Tomato	Alternaria blight, Bacterial spot, Bacterial canker	122	25
Turnip	Same as for broccoli	122	15

[1] Not very satisfactory on account of possibility of seed injury.

Because hot-water treatments require care, accuracy, and the proper equipment (fig. 4), they are usually best performed at a central treating station where adequate facilities are available.

FIGURE 4.—Apparatus for hot-water seed treatment used in Nassau County, N. Y.

Hot-water treatment is a disinfecting process. It does not protect the seed against attacks of soil organisms. Therefore it is usually desirable to follow hot-water treatments with one of the chemical protectants recommended for the particular kind of seed. (See Seed Treatment Chart, pp. 2 to 4.)

22. Fermentation Soak.—The fermentation method of freeing tomato seed from the bacterial canker organism may be used most advantageously by seed producers who separate their tomato seed from the pulp by the fermentation method. The method consists of prolonging the fermentation period from the usual 24 hours to 96 hours at a mean temperature of 70° F. or below.

The fruit should be crushed and thoroughly liquefied at the beginning of the treatment. The pulp should be stirred twice a day to keep all seeds and particles of fruit and skin in contact with the fermenting liquid. At the end of the 4-day period, wash out the seed and dry it in containers free from bacterial contamination. Fermentation darkens the seed.

23. Acetic Acid.—The acetic acid seed soak to rid tomato seed of the germs causing bacterial canker may be used by seed producers who extract seed by machinery designed to free the seed from the fruit pulp in one operation. In such cases the treatment is applied to the moist seed. However, it may be applied by seedsmen or growers to dry seed in a less concentrated form.

For treating moist seed, immediately following extraction, soak the seed for 24 hours in an 0.8-percent solution of acetic acid and water at a mean temperature not in excess of 70° F. At lower mean temperatures concentrations of acetic acid up to 1 percent may be used safely.

Soak dry seed for 24 hours in a 0.6-percent solution of acetic acid at a mean temperature not in excess of 70° F.

Seed should be exposed to the acetic acid in a free state or confined in loosely tied cheesecloth or other porous cloth bag and agitated to insure uniform and complete exposure of all seed.

24. Use of aged seed.

CELERY—The use of seed 2 years old or older as an aid in the control of late blight is suggested. This seed should not be treated with hot water.

25. Spergon (chloranil).—This organic, nonmetallic dust fungicide has been used successfully on peas and beans principally as a seed protectant. The manufacturers suggest that the seed be uniformly coated with the dust at the rate of 2 ounces per bushel.

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